BRITISH STANDARD

BS ISO 80000-11:2008

Quantities and units

Part 11: Characteristic numbers

ICS 1.060

British Standards

National foreword

This British Standard is the UK implementation of ISO 80000-11:2008. It supersedes BS ISO 31-12:1992 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee SS/7, General metrology, quantities, units and symbols.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 80000-11 was prepared by Technical Committee ISO/TC 12, *Quantities, units, symbols, conversion factors* in co-operation with IEC/TC 25, *Quantities and units*.

This first edition of ISO 80000-11 cancels and replaces the third edition of ISO 31-12:1992 and ISO 31-12:1992/Amd.1:1998. The major technical changes from the previous standard are the following:

— the *normative references* have been changed.

ISO 80000 consists of the following parts, under the general title *Quantities and units*:

— *Part 1: General*

— *Part 2: Mathematical signs and symbols to be used in the natural sciences and technology*

— *Part 3: Space and time*

— *Part 4: Mechanics*

— *Part 5: Thermodynamics*

— *Part 7: Light*

— *Part 8: Acoustics*

— *Part 9: Physical chemistry and molecular physics*

— *Part 10: Atomic and nuclear physics*

— *Part 11: Characteristic numbers*

— *Part 12: Solid state physics*

IEC 80000 consists of the following parts, under the general title *Quantities and units*:

— *Part 6: Electromagnetism*

— *Part 13: Information science and technology*

— *Part 14: Telebiometrics related to human physiology*

Introduction

0.1 Arrangements of the tables

All characteristic numbers are quantities of *dimension one*. Hence the coherent unit of all characteristic numbers is the number one, symbol 1. This unit is not repeated in the following tables.

Where the numbering of an item has been changed in the revision of a part of ISO 31, the number in the preceding edition is shown in parenthesis under the new number for the quantity; a dash is used to indicate that the item in question did not appear in the preceding edition.

0.2 Tables of quantities

The names in English and in French of the most important quantities within the field of this document are given together with their symbols and, in most cases, their definitions. These names and symbols are recommendations. The definitions are given for identification of the quantities in the International System of Quantities (ISQ), listed in the tables; they are not intended to be complete.

The scalar, vectorial or tensorial character of quantities is pointed out, especially when this is needed for the definitions.

In most cases, only one name and only one symbol for the quantity are given; where two or more names or two or more symbols are given for one quantity and no special distinction is made, they are on an equal footing. When two types of italic letters exist (for example as with ϑ and θ; φ and ϕ; *a* and a; *g* and g), only one of these is given. This does not mean that the other is not equally acceptable. It is recommended that such variants should not be given different meanings. A symbol within parenthesis implies that it is a reserve symbol, to be used when, in a particular context, the main symbol is in use with a different meaning.

In this English edition, the quantity names in French are printed in an italic font, and are preceded by *fr*. The gender of the French name is indicated by (m) for masculine and (f) for feminine, immediately after the noun in the French name.

0.3 Remark on units for quantities of dimension one, or dimensionless quantities

The coherent unit for any quantity of dimension one, also called a dimensionless quantity, is the number one, symbol 1. When the value of such a quantity is expressed, the unit symbol 1 is generally not written out explicitly.

EXAMPLE 1 Refractive index $n = 1{,}53 \times 1 = 1{,}53$

Prefixes shall not be used to form multiples or submultiples of this unit. Instead of prefixes, powers of 10 are recommended.

EXAMPLE 2 Reynolds number $Re = 1{,}32 \times 10^3$

Considering that plane angle is generally expressed as the ratio of two lengths and solid angle as the ratio of two areas, in 1995 the CGPM specified that, in the SI, the radian, symbol rad, and steradian, symbol sr, are dimensionless derived units. This implies that the quantities plane angle and solid angle are considered as derived quantities of dimension one. The units radian and steradian are thus equal to one; they may either be omitted, or they may be used in expressions for derived units to facilitate distinction between quantities of different kind but having the same dimension.

Quantities and units —

Part 11: Characteristic numbers

1 Scope

ISO 80000-11 gives the names, symbols and definitions for characteristic numbers used in the description of transport phenomena.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 80000-3:2006, *Quantities and units — Part 3: Space and time*

ISO 80000-4:2006, *Quantities and units — Part 4: Mechanics*

ISO 80000-5:2007, *Quantities and units — Part 5: Thermodynamics*

IEC 80000-6:2008, *Quantities and units — Part 6: Electromagnetism*

ISO 80000-8:2007, *Quantities and units — Part 8: Acoustics*

ISO 80000-9:—[1)], *Quantities and units — Part 9: Physical chemistry and molecular physics*

3 Names, symbols, and definitions

The names, symbols, and definitions for characteristic numbers are given on the following pages.

1) To be published. (Revision of ISO 31-8:1992)

4 Momentum transport

Item No.	Name	Symbol	Definition	Remarks
11-4.1 (*12-1*)	Reynolds number *fr nombre* (m) *de Reynolds*	Re	$$Re = \frac{\rho v l}{\eta} = \frac{v l}{\nu}$$ where ρ is mass density (ISO 80000-4:2006, item 4-2), v is speed (ISO 80000-3:2006, item 3-8.1), l is length (ISO 80000-3:2006, item 3-1.1), η is dynamic viscosity (ISO 80000-4:2006, item 4-23), and ν is kinematic viscosity (ISO 80000-4:2006, item 4-24)	
11-4.2 (*12-2*)	Euler number *fr nombre* (m) *d'Euler*	Eu	$$Eu = \frac{\Delta p}{\rho v^2}$$ where p is pressure (ISO 80000-4:2006, item 4-15.1), ρ is mass density (ISO 80000-4:2006, item 4-2), and v is speed (ISO 80000-3:2006, item 3-8.1)	Sometimes the double of the Euler number as defined here is called the Euler number. That definition is deprecated.
11-4.3 (*12-3*)	Froude number *fr nombre* (m) *de Froude*	Fr	$$Fr = \frac{v}{\sqrt{lg}}$$ where v is speed (ISO 80000-3:2006, item 3-8.1), l is length (ISO 80000-3:2006, item 3-1.1), and g is acceleration of free fall (ISO 80000-3:2006, item 3-9.2)	Sometimes the square of the Froude number as defined here is called the Froude number. That definition is deprecated.
11-4.4 (*12-4*)	Grashof number *fr nombre* (m) *de Grashof*	Gr	$$Gr = \frac{l^3 g \alpha \Delta T}{\nu^2}$$ where l is length (ISO 80000-3:2006, item 3-1.1), g is acceleration of free fall (ISO 80000-3:2006, item 3-9.2), α is cubic expansion coefficient (ISO 80000-5:2007, item 5-3.2), T is thermodynamic temperature (ISO 80000-5:2007, item 5-1), and ν is kinematic viscosity (ISO 80000-4:2006, item 4-24)	
11-4.5 (*12-5*)	Weber number *fr nombre* (m) *de Weber*	We	$$We = \frac{\rho v^2 l}{\sigma}$$ where ρ is mass density (ISO 80000-4:2006, item 4-2), v is speed (ISO 80000-3:2006, item 3-8.1), l is length (ISO 80000-3:2006, item 3-1.1), and σ is surface tension (ISO 80000-4:2006, item 4-25)	

(continued)

Item No.	Name	Symbol	Definition	Remarks
11-4.6 (*12-6*)	Mach number *fr nombre* (m) *de Mach*	Ma	$Ma = v/c$ where v is speed (ISO 80000-3:2006, item 3-8.1) and c is speed of sound (ISO 80000-8:2007, item 8-14.1)	
11-4.7 (*12-7*)	Knudsen number *fr nombre* (m) *de Knudsen*	Kn	$Kn = \lambda/l$ where λ is mean free path (ISO 80000-9:—, item 9-38) and l is length (ISO 80000-3:2006, item 3-1.1)	
11-4.8 (*12-8*)	Strouhal number *fr nombre* (m) *de Strouhal*	Sr	$Sr = lf/v$ where l is length (ISO 80000-3:2006, item 3-1.1), f is frequency (ISO 80000-3:2006, item 3-15.1), and v is speed (ISO 80000-3:2006, item 3-8.1)	

(concluded)

5 Transport of heat

Item No.	Name	Symbol	Definition	Remarks
11-5.1 (*12-9*)	Fourier number *fr nombre* (m) *de Fourier*	Fo	$$Fo = \frac{\lambda t}{c_p \rho l^2} = \frac{at}{l^2}$$ where λ is thermal conductivity (ISO 80000-5:2007, item 5-9), t is time (ISO 80000-3:2006, item 3-7), c_p is specific heat capacity at constant pressure (ISO 80000-5:2007, item 5-16.2), ρ is mass density (ISO 80000-4:2006, item 4-2), l is length (ISO 80000-3:2006, item 3-1.1), and a is thermal diffusivity (ISO 80000-5:2007, item 5-14)	
11-5.2 (*12-10*)	Péclet number *fr nombre* (m) *de Péclet*	Pe	$$Pe = \frac{\rho c_p v l}{\lambda} = \frac{vl}{a}$$ where ρ is mass density (ISO 80000-4:2006, item 4-2), c_p is specific heat capacity at constant pressure (ISO 80000-5:2007, item 5-16.2), v is speed (ISO 80000-3:2006, item 3-8.1), l is length (ISO 80000-3:2006, item 3-1.1), λ is thermal conductivity (ISO 80000-5:2007, item 5-9), and a is thermal diffusivity (ISO 80000-5:2007, item 5-14)	$Pe = Re \cdot Pr$
11-5.3 (*12-11*)	Rayleigh number *fr nombre* (m) *de Rayleigh*	Ra	$$Ra = \frac{l^3 \rho^2 c_p g \alpha \Delta T}{\eta \lambda} = \frac{l^3 g \alpha \Delta T}{\nu a}$$ where l is length (ISO 80000-3:2006, item 3-1.1), ρ is mass density (ISO 80000-4:2006, item 4-2), c_p is specific heat capacity at constant pressure (ISO 80000-5:2007, item 5-16.2), g is acceleration of free fall (ISO 80000-3:2006, item 3-9.2), α is cubic expansion coefficient (ISO 80000-5:2007, item 5-3.2), T is thermodynamic temperature (ISO 80000-5:2007, item 5-1), η is dynamic viscosity (ISO 80000-4:2006, item 4-23), λ is thermal conductivity (ISO 80000-5:2007, item 5-9), ν is kinematic viscosity (ISO 80000-4:2006, item 4-24), and a is thermal diffusivity (ISO 80000-5:2007, item 5-14)	$Ra = Gr \cdot Pr$

(continued)

Item No.	Name	Symbol	Definition	Remarks
11-5.4 (*12-12*)	Nusselt number *fr nombre* (m) *de Nusselt*	Nu	$$Nu = \frac{Kl}{\lambda}$$ where K is coefficient of heat transfer (ISO 80000-5:2007, item 5-10.1), l is length (ISO 80000-3:2006, item 3-1.1), and λ is thermal conductivity (ISO 80000-5:2007, item 5-9)	The name Biot number, Bi, is used when the Nusselt number is reserved for convective transport of heat.
11-5.5 (—)	Biot number *fr nombre* (m) *de Biot*	Bi	$$Bi = \frac{Kl}{\lambda}$$ where K is coefficient of heat transfer (ISO 80000-5:2007, item 5-10.1), l is length (ISO 80000-3:2006, item 3-1.1), and λ is thermal conductivity (ISO 80000-5:2007, item 5-9) of a solid	
11-5.6 (*12-13*)	Stanton number *fr nombre* (m) *de Stanton*	St	$$St = \frac{K}{\rho v c_p}$$ where K is coefficient of heat transfer (ISO 80000-5:2007, item 5-10.1), ρ is mass density (ISO 80000-4:2006, item 4-2), v is speed (ISO 80000-3:2006, item 3-8.1), and c_p is specific heat capacity at constant pressure (ISO 80000-5:2007, item 5-16.2)	$St = Nu/Pe$ Sometimes called the Margoulis number, Ms. The number $j = St \cdot Pr^{2/3}$ is called heat transfer factor.

(concluded)

6 Transport of matter in a binary mixture

Item No.	Name	Symbol	Definition	Remarks
11-6.1 (*12-14*)	Fourier number for mass transfer *fr* *nombre* (m) *de Fourier pour transfert de masse*	Fo^*	$$Fo^* = \frac{Dt}{l^2}$$ where D is diffusion coefficient (ISO 80000-9:—, item 9-39), t is time (ISO 80000-3:2006, item 3-7), and l is length (ISO 80000-3:2006, item 3-1.1)	$Fo^* = Fo/Le$ Compare item 11-5.1.
11-6.2 (*12-15*)	Péclet number for mass transfer *fr* *nombre* (m) *de Péclet pour transfert de masse*	Pe^*	$$Pe^* = \frac{vl}{D}$$ where v is speed (ISO 80000-3:2006, item 3-8.1), l is length (ISO 80000-3:2006, item 3-1.1), and D is diffusion coefficient (ISO 80000-9:—, item 9-39)	$Pe^* = Re \cdot Sc = Pe \cdot Le$ Compare item 11-5.2.
11-6.3 (*12-16*)	Grashof number for mass transfer *fr* *nombre* (m) *de Grashof pour transfert de masse*	Gr^*	$$Gr^* = \frac{l^3 g \beta \Delta x}{v^2}$$ where l is length (ISO 80000-3:2006, item 3-1.1), g is acceleration of free fall (ISO 80000-3:2006, item 3-9.2), $\beta = -(1/\rho)(\partial\rho/\partial x)_{T,p}$, ρ is mass density (ISO 80000-4:2006, item 4-2), x is amount-of-substance fraction (ISO 80000-9:—, item 9-14.1), and v is speed (ISO 80000-3:2006, item 3-8.1)	Compare item 11-4.4.
11-6.4 (*12-17*)	Nusselt number for mass transfer *fr* *nombre* (m) *de Nusselt pour transfert de masse*	Nu^*	$$Nu^* = \frac{kl}{\rho D}$$ where k is the mass transfer coefficient: $(m/t)/(A\,\Delta x)$, m is mass (ISO 80000-4:2006, item 4-1), t is time (ISO 80000-3:2006, item 3-7), A is area (ISO 80000-3:2006, item 3-3), x is amount-of-substance fraction (ISO 80000-9:—, item 9-14.1), l is length (ISO 80000-3:2006, item 3-1.1), ρ is mass density (ISO 80000-4:2006, item 4-2), and D is diffusion coefficient (ISO 80000-9:—, item 9-39)	Sometimes called the Sherwood number, Sh. Compare item 11-5.4.

(continued)

Item No.	Name	Symbol	Definition	Remarks
11-6.5 (*12-18*)	Stanton number for mass transfer *fr nombre* (m) *de Stanton pour transfert de masse*	St^*	$$St^* = \frac{k}{\rho v}$$ where k is mass transfer coefficient: $(m/t)/(A\,\Delta x)$, m is mass (ISO 80000-4:2006, item 4-1), t is time (ISO 80000-3:2006, item 3-7), A is area (ISO 80000-3:2006, item 3-3), x is amount-of-substance fraction (ISO 80000-9:—, item 9-14.1), ρ is mass density (ISO 80000-4:2006, item 4-2), and v is speed (ISO 80000-3:2006, item 3-8.1)	$St^* = Nu^*/Pe^*$ Compare item 11-5.5. Sometimes called the Margoulis number, Ms. The number $j_m = St^* \cdot Sc^{2/3}$ is called mass transfer factor.

(concluded)

7 Constants of matter

Item No.	Name	Symbol	Definition	Remarks
11-7.1 (*12-19*)	Prandtl number *fr nombre* (m) *de Prandtl*	Pr	$$Pr = \frac{\eta c_p}{\lambda} = \frac{\nu}{a}$$ where η is dynamic viscosity (ISO 80000-4:2006, item 4-23), c_p is specific heat capacity at constant pressure (ISO 80000-5:2007 item 5-16.2), λ is thermal conductivity (ISO 80000-5:2007, item 5-9), ν is kinematic viscosity (ISO 80000-4:2006, item 4-24), and a is thermal diffusivity (ISO 80000-5:2007, item 5-14)	
11-7.2 (*12-20*)	Schmidt number *fr nombre* (m) *de Schmidt*	Sc	$$Sc = \frac{\eta}{\rho D} = \frac{\nu}{D}$$ where η is dynamic viscosity (ISO 80000-4:2006, item 4-23), ρ is mass density (ISO 80000-4:2006, item 4-2), D is diffusion coefficient (ISO 80000-9:—, item 9-39), and ν is kinematic viscosity (ISO 80000-4:2006, item 4-24)	
11-7.3 (*12-21*)	Lewis number *fr nombre* (m) *de Lewis*	Le	$$Le = \frac{\lambda}{\rho c_p D} = \frac{a}{D}$$ where λ is thermal conductivity (ISO 80000-5:2007 item 5-9), ρ is mass density (ISO 80000-4:2006, item 4-2), c_p is specific heat capacity at constant pressure (ISO 80000-5:2007, item 5-16.2), D is diffusion coefficient (ISO 80000-9:—, item 9-39), and a is thermal diffusivity (ISO 80000-5:2007, item 5-14)	Compare item 11-5.2.

8 Magnetohydrodynamics

Item No.	Name	Symbol	Definition	Remarks
11-8.1 (*12-22*)	magnetic Reynolds number *fr nombre* (m) *de Reynolds magnétique*	Rm	$Rm = v\mu\sigma l$ where v is speed (ISO 80000-3:2006, item 3-8.1), μ is magnetic permeability (IEC 80000-6:2008, item 6-26.2), σ is electrical conductivity (IEC 80000-6:2008, item 6-43), and l is length (ISO 80000-3:2006, item 3-1.1)	
11-8.2 (*12-23*)	Alfvén number *fr nombre* (m) *d'Alfvén*	Al	$Al = \frac{v}{B/(\rho\mu)^{1/2}} = \frac{v}{v_\mathrm{A}}$ where v is speed (ISO 80000-3:2006, item 3-8.1), B is magnetic flux density (IEC 80000-6:2008, item 6-21), ρ is mass density (ISO 80000-4:2006, item 4-2), μ is magnetic permeability (IEC 80000-6:2008, item 6-26.2), and v_A is Alfvén speed: $B/(\rho\mu)^{1/2}$	
11-8.3 (*12-24*)	Hartmann number *fr nombre* (m) *de Hartmann*	Ha	$Ha = Bl\left(\frac{\sigma}{\rho\nu}\right)^{1/2}$ where B is magnetic flux density (IEC 80000-6:2008, item 6-21), l is length (ISO 80000-3:2006, item 3-1.1), σ is electric conductivity (IEC 80000-6:2008, item 6-43), ρ is mass density (ISO 80000-4:2006, item 4-2), and ν is kinematic viscosity (ISO 80000-4:2006, item 4-24)	
11-8.4 (*12-25*)	Cowling number *fr nombre* (m) *de Cowling*	Co	$Co = \frac{B^2}{\mu\rho v^2}$ where B is magnetic flux density (IEC 80000-6:2008, item 6-21), μ is magnetic permeability (IEC 80000-6:2008, item 6-26.2), ρ is mass density (ISO 80000-4:2006, item 4-2), and ν is kinematic viscosity (ISO 80000-4:2006, item 4-24)	$Co = (v_\mathrm{A}/v)^2 = Al^{-2}$ Often called the second Cowling number, Co_2. The first Cowling number is often defined as $Co_1 = Ha^2/Re = \frac{B^2 l\sigma}{\rho\nu} = Co \cdot Rm$

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